Propagate Plants from Cuttings Using Foliar-Applied Aqueous (Water-Based) IBA Rooting Solutions: Tips — Do's and Don'ts©

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Today growers worldwide successfully propagate plants from cuttings using foliar applied aqueous (water-based) IBA rooting solutions. They use the Spray Drip Down and Total Immerse Methods. Leafy cuttings are taken from annual, perennial, and woody plants in the growing season. Compared with other propagation methods, foliar application has significant labor and material cost savings. Cuttings are treated in bulk at low rates.

A BRIEF HISTORY OF FOLIAR APPLIED IBA ROOTING SOLUTIONS

More than 25 years ago growers who wanted to propagate plants from cuttings by using rooting hormones were limited to basal application. Scientists had known plants produce growth substances (rooting hormones) in leaves. Charles Darwin, in his book *The Power of Movement in Plants* (1880), described his study of the production and flow of these substances from the leaves to the lower portions of the plant. Scientists later identified the substances produced by plants. Called auxins, indole-3-acetic acid (IAA) and later indole-3-butyric acid (IBA) have been identified as natural rooting hormones. Commercial rooting hormones became available. As scientists and growers advanced procedures to propagate plants from cuttings they only focused on basal application of rooting hormones. They did not consider that foliar application of rooting hormones would naturally translocate to the basal end of cuttings where it can induce root formation.

Dr. Frederick Davies did histological and physiological studies on the foliar application of aqueous IBA rooting solutions (1978). Indole-3-butyric acid is a well used root promoting substance. The studies were concurrent with his propagation work comparing root formation in juvenile and mature cuttings.

In 1985 Kees Eigenraam, the technical advisor at Rhizopon, introduced to Dutch growers the foliar application of IBA rooting solutions to propagate plants from cuttings. At the time, Kees did not know the research by Dr. Davies. Kees and Joel Kroin began to formalize the foliar techniques later named the Spray Drip Down and Total Immerse Methods. By the early 1990s they introduced these techniques to USA growers. Initially growers of annual plants adopted the methods. Soon after, growers at Yoder (now Aris), Green Leaf Plants, and Keepsake Plants began using the Spray Drip Down Method on their many perennial plant taxa. They also developed a foliar program on their Yoder brand chrysanthemums. After 2000, Sam Drahn's studies at Bailey Nurseries led to their extensive use of the Spray Drip Down Method on woody ornamental plant cuttings (Fig. 1).

METHODS TO PROPAGATE PLANTS FROM CUTTINGS

Currently five methods are used to propagate plants from cuttings. No one method is best for all plant taxa under all situations. Use the optimum foliar and/or basal methods as needed for the plants and operation of the facility.

Basal Methods

Three methods are used to apply rooting hormones to the basal end of cuttings. The methods are used all year depending upon the condition of the cuttings.

Using dry powder rooting hormones ready for use:

- Basal dry dip method.

Using rooting solutions:

- Basal quick dip method.

• Basal long soak method.

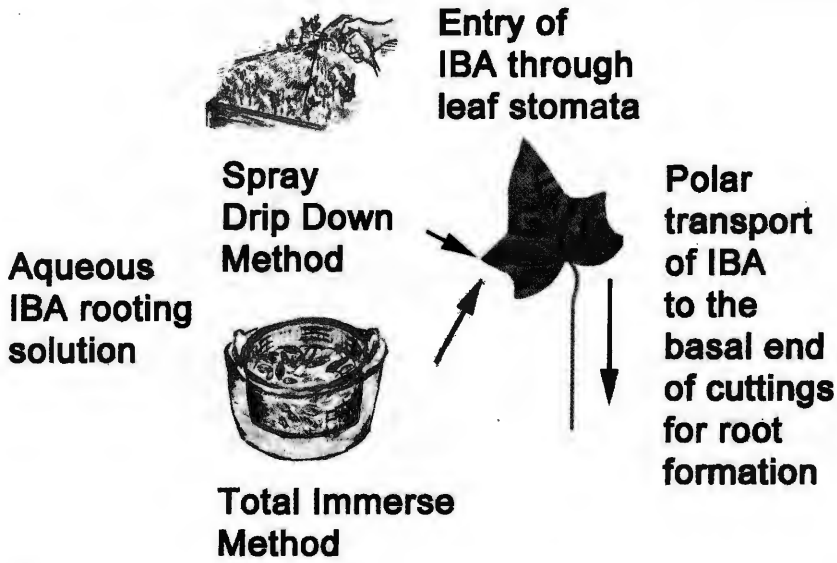

Fig. 1. Plant propagation by cuttings using foliar applied aqueous rooting solutions.

Foliar Methods

Two methods are used to apply rooting solutions to the leaves of cuttings. The methods are used on leafy cuttings taken during the growing season. They are not used on leafless or dormant cuttings. Using aqueous (water-based) IBA rooting solutions:

- Spray drip down method
- Total immerse method

How does foliar application work? Leafy cuttings are taken from stock plants in the growing season. The leaves of plant cuttings are treated with aqueous (water-based) IBA solutions. Indole-3-butyric acid can enter the vascular system through open pores in the stomata. Stomata are open in a temperature range from about 60-90°F (15-33°C) and when cuttings are well hydrated before treatment.

- A large number of IBA particles are deposited on the leaves. The amount is in excess of the amount that the plant needs for growth regulation (Fig. 2).
- The IBA translocates through the plant's vascular system, by polar (one way) transport, to the basal end of the cuttings (Fig. 2).
- At some time in the flow, apparently the plant is able to identify it's need for the newly arrived IBA. Somehow some of the surplus IBA is sent away from the basal end.
- Though the rooting hormones have been known and studied since the 1930s, scientists are still uncertain how they are transported, induce root cell division and root formation.
- At the basal end IBA interacts with IAA, another natural rooting hormone, to induce root formation.

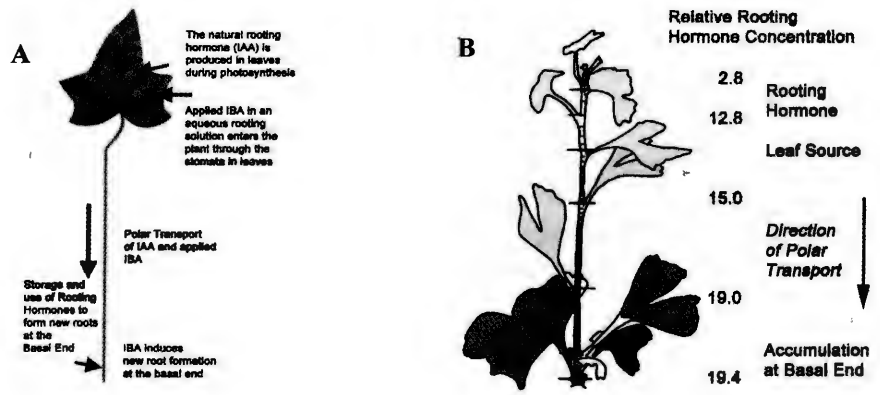

Fig. 2. A: Polar transport in cuttings of applied IBA and IAA rooting hormones. B: Relative concentration gradient of rooting hormones in a cutting based on Thimann (1977).

We can look at the IBA flow like a ferryboat (carrier) model:
The ferry boat:

- Boats pickup an increasing number of passengers on the departure side.
- Passengers are transported across the river to a small arrival loading dock.
- The loading dock fills to capacity.
- If overload, some passengers are carried back.

We can make a carrier model for the foliar applied IBA (Fig. 3):

- A large number of IBA particles in a rooting solution is applied to the broad area of leaves.
- IBA enters the plant's system vascular system through pores in open stomata. It is polar transported through in the phloem to the basal end.
- The amount of IBA needed by the plant is accumulated at the small basal site. There the IBA, in coordination with the other natural rooting hormone IAA, initiates roots.
- For the un-needed amount, the excess IBA is returned to the leaves in a non-polar route. The returned IBA may cause tender leaf deformities on existing leaves.
- New leaves and roots form normally.

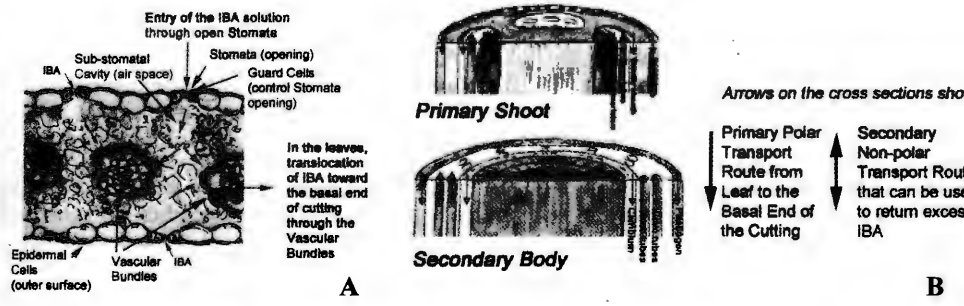

Fig. 3. A: Leaf cross section showing entry of IBA through stomata. B: Free IBA transport from leaves to the basal end of cuttings through primary shoots and secondary stem.

1. Low Labor Cost. Foliar methods require less labor than basal methods. It is faster to stick cuttings when they are batch treated as compared with individual basal treatment, and low foliar rates means low material cost.
2. Temperature When Treating. For foliar methods do not apply when the cuttings and solutions are at low or high ambient temperatures. Use foliar application when the temperature of both the solution and cuttings are at about 60-90°F (15-33°C).

Total Immerse Method
- Use a tub and strainer basket (Fig. 4).
- Dip the cuttings in the solution until the leaves are completely covered with liquid, about 5 sec.
- Drain.
- Stick the cuttings into media.

Some benefits:
- Simple equipment is used.
- The total immerse method can be used for large homogeneous plant lots that are clean and free of diseases.
- The method requires little setup and it can be used on small lots.
- Can be used to treat large leaves that may be difficult to spray uniformly.

Fig. 4. Total immerse method.

Spray Drip Down Method
- Stick the cuttings into media.
- Use the selected sprayer.
- Spray the solution onto the leaves of the cuttings until there is a drip down. The drips are visual indicator that an adequate amount of solution has been applied. The top and bottom of cuttings should be treated.
- Excess application is best.
- The solution gets sucked by capillary action into the plant. Wait about 30-45 min or until the solution dries on the leaves, then turn on misters.
- Typical solution use is about 200 sf/gallon (10 $m^{-2} \cdot L^{-1}$).

Some benefits:
- No personal protective equipment is required for sticking untreated cuttings.
- The spray drip down method can be used on many small production lots at one time.

• The solutions are used one time. There can be no cross contamination between production lots due to biological matter going into the solution.

A

B

Fig. 5. A: spraying cuttings after sticking. B: spraying cuttings until solution drips down.

1. Sticking and Treatment Timing.
• Apply by the Spray Drip Down Method within the day of sticking.
• For cuttings kept in a hot climate, such as southern Florida, cuttings are stuck during the day and treated early the following morning.

2. Cutting Hydration and Misting. Well hydrate cuttings before foliar treatment:
• Hydrate cuttings before treating to assure the stomata are open. This will allow the IBA solution to enter the vascular system.
• Wilted cuttings have closed stomata. The cuttings must be fully hydrated before treatment.

Well hydrate cuttings after foliar treatment:
• When using the Total Immerse Method, misters can be turned on any time after sticking. There is always a lag time between treatment and sticking.
• When using the Spray Drip Down Method, wait to turn on misters about 30-45 min or until the solution dries on the leaves.
• Some growers of chrysanthemum find they get better rooting when they let the cuttings lose turgor before turning on misters.

Rooting Solutions for Foliar Methods

Foliar methods use aqueous (water-based) IBA solutions (Table 1). Water is the natural fluid in plants that is used to translocate natural rooting substances.

The US EPA requires registration of IBA rooting products. There are only two registered products used to make water-based IBA rooting solutions and labeled for foliar application. These products are: Hortus IBA Water Soluble Salts. (Distributed by Phytotronics, phytotronics.com, <sales@phytotronics.com>) and Rhizopon AA Water Soluble Tablets (Distributed by Phytotronics, (URL: <phytotronics.com>).

Only use water-based solutions do not use alcohol-base IBA rooting solutions when using foliar application. Alcohol dehydrates plant tissue and causes cutting fatality called "alcohol burn." When using foliar methods do not use wetting agents in solutions made with Hortus IBA Water Soluble Salts and Rhizopon AA Water Soluble Tablets.

1. Make Concentrate Rooting Solutions. It is sometimes easier to measure and mix solutions rather than dry measure the salts or tablets for many production tanks. In those cases make up a solution concentrate at the required number of grams or tablets, then, decant the solution into the production tank. Add water to bring the tank to the required volume. Do not use dry powder rooting hormones. Dry powder rooting hormone products, like Rhizopon AA #1, #2, and #3, are not used by foliar application. These products are insoluble in water.

2. Foliar Rates.

Annual Cuttings. Annual cuttings require low rates. Some tender plant taxa and juvenile cuttings are treated at rates 80-100 ppm IBA. If rates are slightly too high there may be

some leaf distortion; the roots may form well and new leaves will be normal. Leaf distortion many not be evident on mature cuttings.

Perennial and Woody Ornamental Plant Cuttings. Perennial and woody plant cuttings have a similar range of rates. The selected trial rates are: 500, 1000, and 1500 ppm IBA. Rates above 1500 ppm IBA are rarely needed except for some mature cuttings. Rates below 500 ppm IBA are sometimes needed for juvenile tender perennial cuttings.

Tissue Culture Plantlets. Use the total immerse method on tissue culture plantlets when transplanting at the third to fifth stages. Blueberry example: use two Rhizopon AA Water Soluble Tablets per liter water.

Table 1. Trial foliar application rates using Hortus IBA Water Soluble Salts and Rhizopon AA water soluble tablets.

Cutting type	Hortus IBA Water Soluble Salts as ppm IBA	Rhizopon AA Water Soluble Tablets in tablets per liter water
Annuals and tender perennials	80-250	1-5
Perennials	250-1500	5-30
Woody ornamental	300-1500	6-30
Tissue culture plantlets at 3rd to 5th stage transplants		1-3

- Juvenile cuttings require lower rates than mature cuttings.
- Growers generally know which of their cuttings are seasonally easy or hard to root. Based upon that knowledge it is best to select trial rates on the appropriate part of the range.
- Do not use the same rates for foliar application as used by the basal quick dip method, they are usually too high.

Use The Proper Equipment and Cutting Material

1. Spray Drip Down Method. Use appropriate spray equipment for the job for labor saving and effectiveness.

2. Total Immerse Method. Use a basket for dipping into the solution tank (Fig. 7A).

- Do not overload the baskets to avoid cutting breakage.
- Do not use a basket or tank made from materials that can corrode.

Figure 7A shows a simple tank and strainer at a *Hedera* (ivy) greenhouse in Europe. Notice the sticking personnel in the background. Figure 7B shows use on tissue culture plants. Few cuttings are in the basket to prevent damage.

3. The Cuttings. Cutting types:

- Use leafy cuttings in the growing season.
- Do not take dormant or leafless cuttings. For those cuttings use basal methods like the dry dip, basal long soak, or basal quick dip methods.

4. Cutting Maturity.

- Do not use hard woody or old mature cuttings.
- Juvenile cuttings are easier to propagate from cuttings compared to those which are mature. When possible, take cuttings from cuttings. Juvenile cuttings require lower IBA rooting solution rates than mature cuttings.
- Bad cuttings cannot be revived.

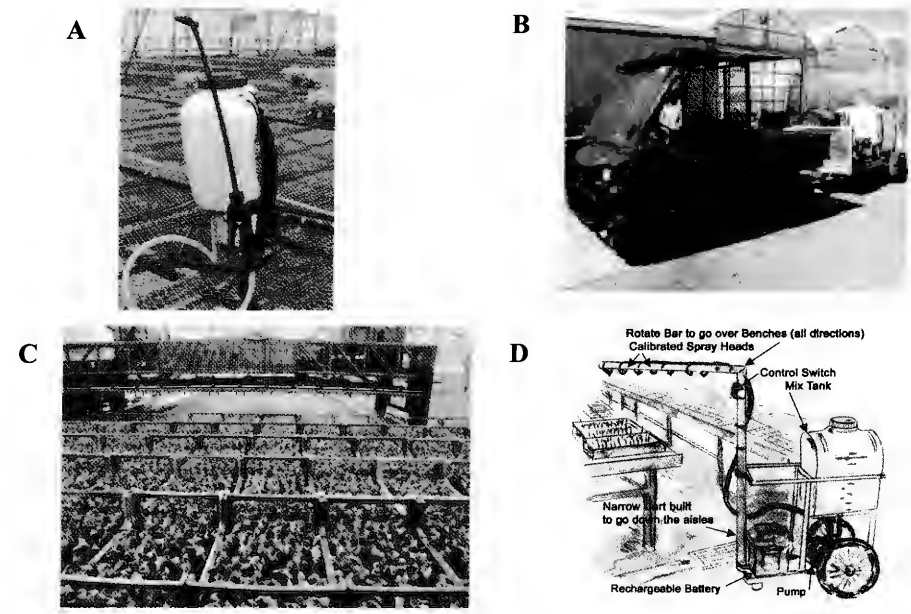

Fig. 6. Typical sprayers: A: Backpack sprayer; B: Hydraulic sprayer (Bailey Nurseries); C: Robotic sprayer on chrysanthemums in Holland; D: Sketch showing a custom spray cart used at Aris Green Leaf Plants in Lancaster Pennsylvania.

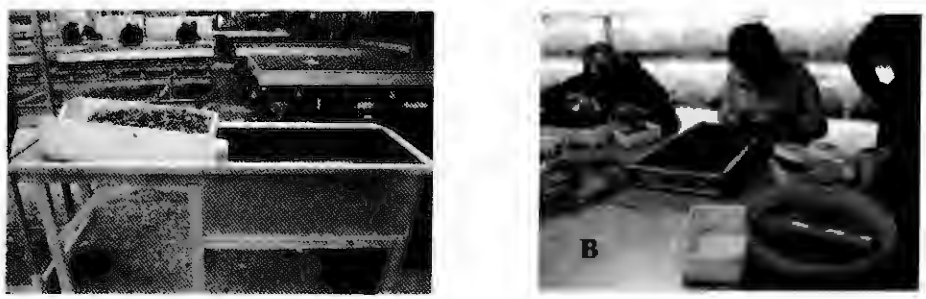

Fig. 7. A: Simple tank and strainer at a *Hedera* (ivy) greenhouse in Europe. B: Use on tissue culture plants.

5. Cutting Nodes and Leaf Tip Cutting. Use cuttings that do not have nodes or buds at the basal end (Fig. 8A). Do not cut leaf tips (Fig. 8B). In "old-school" for propagation by other methods, some growers cut the tips of large leaf cuttings to obtain more cuttings in a propagation tray.

There are reasons NOT to cut the tips:

- The cut causes a wound that is open to infection.
- The cuttings have reduced natural rooting substance IAA formed at a usual place, the tips of leaves. The natural IAA works with the applied IBA to induce roots. With the tips cut, there is less IAA available.
- With a wound present, the cuttings use valuable resources to heal, rather than induce root formation.

- Growing compact stock plants allows taking cuttings from an earlier stage where the preferred leaves are smaller.

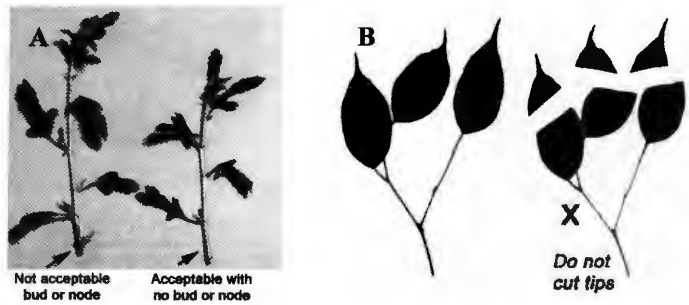

Fig. 8. A: Photo shows without node or bud at basal end; B: Photo shows cutting without tips cut.

IMPORTANCE OF THE STOMATA

Stomata are located on outside surfaces of plants. When stomata pores open they allow fluid, vapor and gas exchanges between the plant and it's environment. Stomata on some plant taxa are more numerous, larger, and on the underside of leaves. In some taxa there are more stomata on the underside.

Stomata functions:

- Open when cuttings are well hydrated.
- Open when temperatures and other factors are suitable for translocation of fluids and air.
- Close when cuttings are wilted.
- Close when protecting the plant from exchanges under harsh environmental conditions.
- Close in the dark and open in the light.

Sometimes identifying the primary stomata side is easy. Leaf curl means the plant is under stress leading to closed stomata interior to the curl.

SECONDARY APPLICATION

For leafy cuttings in the growing state that were first treated by any method, secondary spray drip down method applications are used. The application levels crops and helps to improve slow-to-root cuttings. Secondary applications are done weekly as required at the standard rates for that type of cutting.

HYBRID PROPAGATION SYSTEMS AND SOLUTION PRODUCT INVENTORY

- Many growers use a hybrid system of both basal and foliar applications in the same facility. By season, foliar methods may be used with some crops, dry powder rooting hormones or basal quick dip for others.
- When using aqueous IBA rooting solutions you can use the same product for both basal and foliar application solution needs. There is no need to stock more than one product.

USE APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT

- Use the most effective personal protective equipment that complies with the product label. Unless otherwise specified, thin waterproof gloves are adequate for handling aqueous (water-based) IBA rooting solutions.

- No chemicals are handled by sticking personal when using the Spray Drip Down Method, therefore no gloves or other PPE are needed. Thin gloves may be used solely for sanitary purposes.

AQUEOUS IBA ROOTING SOLUTION DISPOSAL

Do not keep unused solutions for more than several weeks. Biological materials in the make-up water, such as untreated water, pond water, or well water, may cause the active ingredient to degrade. Based upon unknown biological factors, the keeping life of the aqueous solutions cannot be defined. It depends upon the quality of the water.

ADVICE FOR METHODS

- The total immerse method drags biological substances into the use tank. Avoid cross contamination in the solutions. Dispose the solution after each production lot or the end of the production day.
- The spray drip down method uses the solution one time. The solutions can be kept until used up. Don't keep the solutions a very long time.

OVERCOMING PROBLEMS

Trials Are Essential

Before doing full production using foliar methods, always do trials on small lots. Select appropriate leafy plants in the growing season.

- Evaluate a range of rates and methods.
- Consider the time of the year that propagation is being done.
- Review the quality of roots produced on the cuttings.
- Study the facility advantages, and labor and setup cost.

Typical Deformities on Tender Plant Cuttings

Leaf curl and spotting are sometimes due to too high an IBA rate, but reversible (Fig. 9).

- When IBA is applied to the leaves of cuttings, it is absorbed into the vascular system then translocated to the basal end by polar transport. At the basal end the IBA is accumulated. If there is an IBA excess, it will move back to the leaves causing leaf deformities such curl or spotting.
- Despite initial leaf irregularities, the cuttings will usually form normal roots and normal new leaves.

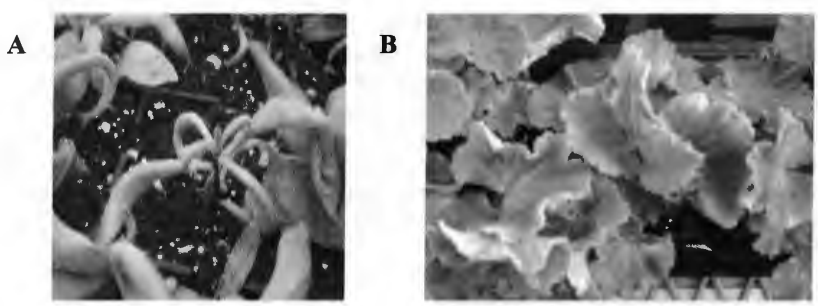

Fig. 9. A: Leaf curling; B: Leaf spotting.

Study Plant Variations

For any successful method of propagation there sometimes may be unexpected results. The method or rate may be considered the culprit even though there was not knowingly change to the rate, method, timing, product, or other factors.

Common problems when using foliar application of rooting solutions is selection of juvenile vs mature cuttings. With excessive rates, juvenile cutting may exhibit distortions in leaves. Juvenile cuttings require lower rates than mature cuttings.

Some of many things to consider:
- Genetic variations of the cuttings: different stock plants.
- Quality of the cuttings.
- Deviations in the growing area such as changes in the environmental control systems and facility.
- Cuttings taken from a different part of the stock area, location, or plantation.
- Timing of taking cuttings from previous.
- Seasonal variations from the norm.

When other reasons are not found, somebody "forgot" to do something!

Hybrid System

To produce an optimum crop it may be beneficial to use several methods concurrently. Foliar methods may be used on a crop at one time of the year and basal methods at another time.
- By season, foliar methods may be used with some crops, dry powder rooting hormones or basal quick dip for others.

CONCLUSIONS

Growers worldwide successfully propagate annual, perennial, and woody plants using:
- Leafy cuttings.
- In the growing season.

Two foliar methods are used:
1) Spray drip down method: cuttings are stuck then sprayed until the solution drips down. Misters are turned on after 30-45 min or when the solution dries.
2) Total immerse method: cuttings are totally immersed in the solution then stuck.

Key factors for foliar method success:
- Make IBA rooting solutions using Hortus IBA Water Soluble Salts and Rhizopon AA Water Soluble Tablets.
- Cuttings are to be well hydrated before treatment.
- Temperatures at time of application should be from about 60-90°F.

All cuttings get uniformly treated: Since all the cuttings are treated in bulk, there is a reduced possibility that some cuttings don't get (basal) treatment by "misses."

Significant labor savings:
- Compared with other propagation methods, foliar application has about one-third the amount of labor used by individual treatment/sticking
- Reduced material cost due to low rates: typical rates for annual cuttings are 80-250 ppm IBA, and perennial and woody plant cuttings rates are typically in the range from 500-1500 ppm IBA. Foliar rates are usually lower than those by the basal quick dip method.

Foliar methods are useful to propagate many plants from cuttings when taken in the growing season. While foliar can be useful, basal methods may be more effective for some cuttings.

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